



BSI Standards Publication

## Fibre optic communication system design guides

---

Part 14: Determination of the uncertainties of attenuation measurements in fibre plants

## National foreword

This Published Document is the UK implementation of IEC TR 61282-14:2019. It supersedes PD IEC/TR 61282-14:2016, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/86/3, Fibre optic systems and active devices.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019  
Published by BSI Standards Limited 2019

ISBN 978 0 539 01246 0

ICS 33.180.01

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 July 2019.

### Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

---



# IEC TR 61282-14

Edition 2.0 2019-07

## TECHNICAL REPORT



---

**Fibre optic communication system design guidelines**  
**Part 14: Determination of the uncertainties of attenuation measurements in fibre plants**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 33.180.01

ISBN 978-2-8322-7069-1

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references .....	8
3 Terms, definitions and abbreviated terms .....	8
3.1 Terms and definitions.....	8
3.2 Abbreviated terms.....	10
4 Overview of uncertainty .....	10
4.1 What is uncertainty? .....	10
4.2 Origin of uncertainties.....	11
4.3 What may not be considered as uncertainty? .....	11
5 Fibre cabling attenuation measurement .....	11
5.1 Test methods .....	11
5.2 Sources of uncertainty to be considered .....	11
5.2.1 Analysis.....	11
5.2.2 Uncertainties due to the environment.....	14
5.2.3 Uncertainties due to operator skills.....	14
5.2.4 Uncertainties due to test methods.....	14
5.2.5 Uncertainties due to measuring instruments.....	14
5.2.6 Uncertainties due to the setup .....	16
5.2.7 Uncertainties due to cabling.....	16
6 Uncertainties estimation .....	17
6.1 Measurement model.....	17
6.2 Accumulation of uncertainties .....	19
7 General representation of the equation using sensitivity coefficients.....	19
8 Calculation .....	23
8.1 Combined standard uncertainty.....	23
8.2 Expanded uncertainty.....	23
8.3 Determination of the coverage factor $k$ .....	23
8.3.1 General approach.....	23
8.3.2 Discussion.....	23
8.3.3 Typical values of degree of freedom .....	24
Annex A (informative) Mathematical basis.....	25
A.1 General.....	25
A.2 Type A evaluation of uncertainty .....	25
A.3 Type B evaluation of uncertainty .....	25
A.4 Determining the combined standard uncertainty.....	26
A.5 Reporting .....	27
Annex B (informative) Test methods .....	28
B.1 Test methods as per IEC 61280-4-1 and 61280-4-2 .....	28
B.1.1 General .....	28
B.1.2 Measurement configuration.....	28
B.1.3 One-cord reference configuration .....	28
B.1.4 Two-cord reference configuration .....	29
B.1.5 Three-cord reference configuration .....	29

B.2	Test methods defined in ISO/IEC 14763-3:2014 .....	29
B.2.1	General .....	29
B.2.2	Channels .....	30
B.2.3	Links .....	31
Annex C (informative)	Uncertainties evaluation .....	32
C.1	Type A uncertainties .....	32
C.1.1	General .....	32
C.1.2	Evaluation of optical source instability and associated uncertainties .....	32
C.2	Type B uncertainties .....	32
C.2.1	General .....	32
C.2.2	Evaluation of the power meter noise .....	32
C.2.3	Elements to be considered for power meter stability analysis .....	33
C.2.4	Evaluation of the centre wavelength dependence .....	33
C.2.5	Spectral width dependence .....	35
C.2.6	Evaluation of the uncertainties due to MM launch conditions .....	35
C.2.7	Evaluation of the PDL .....	36
C.2.8	Uncertainty of absolute power measurement .....	37
Annex D (informative)	Typical values of uncertainties .....	38
Annex E (informative)	Linear to dB scale conversion of uncertainties .....	40
E.1	Definition of decibel .....	40
E.2	Conversion of relative uncertainties .....	40
Bibliography	.....	41
Figure 1	– Fishbone analysis .....	13
Figure 2	– Measurement model .....	17
Figure B.1	– Measurement configuration .....	28
Figure B.2	– One-cord reference measurement .....	28
Figure B.3	– Two-cord reference measurement .....	29
Figure B.4	– Three-cord reference measurement .....	29
Figure B.5	– Measurement on channel .....	30
Figure B.6	– Channel reference measurement .....	30
Figure B.7	– Link measurement configuration .....	31
Figure B.8	– Link reference measurement .....	31
Figure C.1	– Typical spectral response of a fibre .....	34
Figure C.2	– Uncertainties due to the launch conditions for a given loss .....	36
Table 1	– Source of uncertainty (raw list) .....	12
Table 2	– Uncertainties due to measuring instruments .....	15
Table 3	– Uncertainties due to the setup .....	16
Table 4	– Uncertainties due to cabling .....	16
Table 5	– Sensitivity coefficients for IEC 61280-4-1 and IEC 61280-4-2 methods .....	21
Table 6	– Sensitivity coefficients for ISO/IEC 14763-3:2014 methods .....	22
Table 7	– Values of $k_{95}$ for different values of $\nu$ .....	24
Table 8	– Typical values of $\nu_i$ .....	24
Table C.1	– Spectral attenuation coefficients .....	34

Table C.2 – Sensitivity coefficients .....	35
Table D.1 – Typical values of uncertainties .....	39

Currently in preview, click buy full version

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**FIBRE OPTIC COMMUNICATION  
SYSTEM DESIGN GUIDELINES –**
**Part 14: Determination of the uncertainties  
of attenuation measurements in fibre plants**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the most recent edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 61282-14, which is a Technical Report, has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This publication contains an attached file titled "Supplemental Data for Section 8" in the form of an Excel spreadsheet. This file is intended to be used as a complement and does not form an integral part of the standard.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) in the title: replacement of "guide" by "guidelines";
- b) text adaptation to allow both standard grade B and reference grade connectors for termination of test cords;
- c) addition of values needed for calculation of uncertainties, when standard grade connectors are used, to Annex D;
- d) correction of minor inconsistencies in Equation (18) and after.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
86C/1572/DTR	86C/1584/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives – Part 2.

A list of all parts in the IEC 61282 series, published under the general title *Fibre optic communication system design guides*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

**IMPORTANT** – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

## INTRODUCTION

The determination of the uncertainty of every measurement is a key activity, which should be performed by applying dedicated methods as extensively presented in reference documents such as ISO/IEC Guide 98-3:2008, *Guide to the uncertainty of measurement (GUM)*.

This document shows a practical application of these methods for the determination of the measurement uncertainty of the attenuation of fibre optic cabling using optical light sources and power meters as defined in IEC 61280-4-1 and IEC 61280-4-2.

It includes the review of all contributing factors to uncertainty (such as launch conditions, spectral width, stability of source, power meter polarization, resolution, linearity, quality of test cord connectors) to determine the overall measurement uncertainty. This part of IEC 61282-14 applies to the measurement of single mode or multimode fibres without restrictions to the fibre parameters, including mode field diameter, core diameter and numerical aperture. However, numerical values given in Clause C.2 and typical values given in Annex D are not valid for multimode fibres types A2, A3 and A4.

The list of uncertainties presented in this document is related to this particular application and should be reconsidered if measurement conditions are not compliant to measurement requirements defined by IEC 61280-4-1 and IEC 61280-4-2.

The reference document for general uncertainty calculations is ISO/IEC Guide 98-3:2008, and this document does not intend to replace it; it only represents an example and should be used in conjunction with ISO/IEC Guide 98-3:2008. A brief introduction to the determination of measurement uncertainty according to ISO/IEC Guide 98-3:2008 is given in Annex A.

This document is associated with a calculation spreadsheet (Excel) containing practical calculations.

## FIBRE OPTIC COMMUNICATION SYSTEM DESIGN GUIDELINES –

### Part 14: Determination of the uncertainties of attenuation measurements in fibre plants

#### 1 Scope

This part of IEC 61282, which is a Technical Report, establishes the detailed analysis and calculation of the uncertainties related to the measurement of the attenuation of both multimode and single mode optical fibre cabling using optical light sources and power meters.

#### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61280-4-1:2009, *Fibre-optic communication subsystem test procedures – Part 4-1: Installed cable plant – Multimode attenuation measurement*

IEC 61280-4-2:2014, *Fibre-optic communication subsystem test procedures – Part 4-2: Installed cable plant – Single-mode attenuation and optical return loss measurement*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

#### 3 Terms, definitions and abbreviated terms

##### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

##### 3.1.1 attenuation

Reduction of optical power induced by transmission through a medium such as cabling

$$L_{\text{dB}} = 10 \times \log_{10}(P_{\text{in}}/P_{\text{out}})$$

where

$P_{\text{in}}$  and  $P_{\text{out}}$  are the power, typically measured in mW, into and out of the cabling

Note 1 to entry: Attenuation is expressed in dB.